Figure 5.2-6. Bulk Gravel Surface Dg – Dune and Trough Comparison
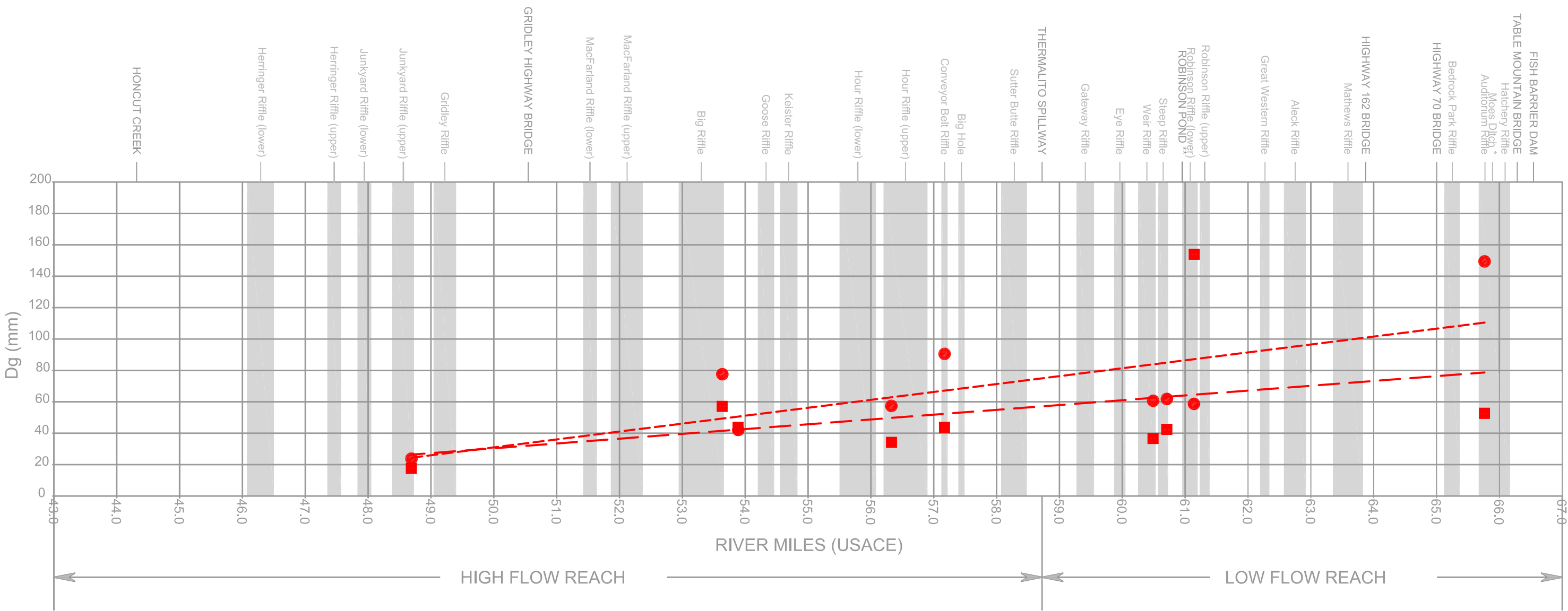
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FIGURE 5.2-6
SP-G2 TASK 2

BULK SURFACE Dg - DUNE
AND TROUGH COMPARISON

Chart axes and labels:

Y-axis: Dg (mm) — 0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200

X-axis: RIVER MILES (USACE) — 43.0, 44.0, 45.0, 46.0, 47.0, 48.0, 49.0, 50.0, 51.0, 52.0, 53.0, 54.0, 55.0, 56.0, 57.0, 58.0, 59.0, 60.0, 61.0, 62.0, 63.0, 64.0, 65.0, 66.0, 67.0

Location labels (top):
HONCUT CREEK, Herringer Riffle (lower), Herringer Riffle (upper), Junkyard Riffle (lower), Junkyard Riffle (upper), Gridley Riffle, GRIDLEY HIGHWAY BRIDGE, MacFarland Riffle (lower), MacFarland Riffle (upper), Big Riffle, Goose Riffle, Keister Riffle, Hour Riffle (lower), Hour Riffle (upper), Conveyor Belt Riffle, Big Hole, Sutter Butte Riffle, THERMALITO SPILLWAY, Gateway Riffle, Eye Riffle, Weir Riffle, Steep Riffle, Robinson Riffle (lower), ROBINSON POND **, Robinson Riffle (upper), Great Western Riffle, Aleck Riffle, Mathews Riffle, HIGHWAY 162 BRIDGE, HIGHWAY 70 BRIDGE, Bedrock Park Riffle, Moe's Ditch *, Auditorium Riffle, Hatchery Riffle, TABLE MOUNTAIN BRIDGE, FISH BARRIER DAM

HIGH FLOW REACH | LOW FLOW REACH

LEGEND
■ 2003 Dune Dg
● 2003 Trough Dg
— — 2003 Dune Dg Linear Best Fit Line
- - - - 2003 Trough Dg Linear Best Fit Line

NOTES
1) River miles based on USACE 1997 river center line. 0.0 = Feather
   River intersection with Sacramento River.
2) * Spawning gravel injection at Moe's Ditch from 1971 to 1982,
   therefore, Linear Best Fits do not include these samples.
3) ** Robinson Pond - apparent gravel trap

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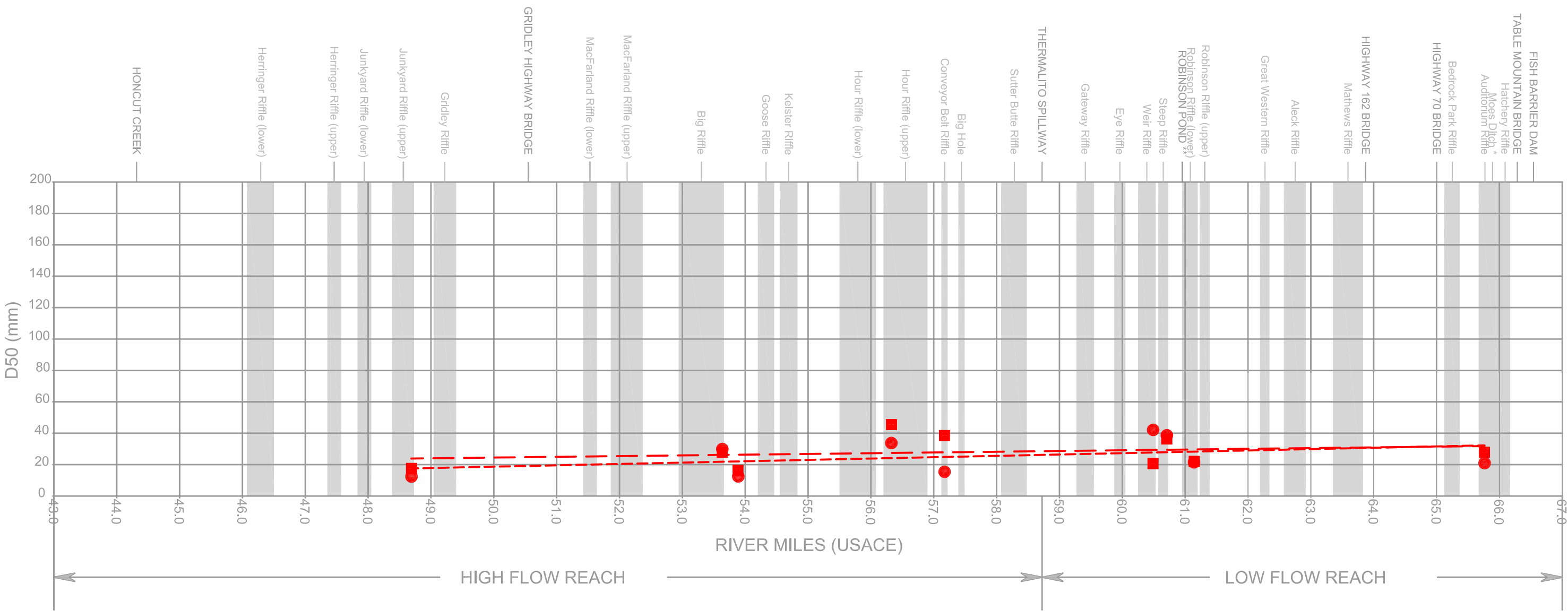FERC Project No. 2100**

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Figure 5.2-7. Bulk Gravel Subsurface D$_{50}$ – Dune and Trough Comparison

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LEGEND

■ 2003 Dune D50

● 2003 Trough D50

— — 2003 Dune D50 Linear Best Fit Line

- - - 2003 Trough D50 Linear Best Fit Line

NOTES

1) River miles based on USACE 1997 river center line. 0.0 = Feather River intersection with Sacramento River.

2) * Spawning gravel injection at Moe's Ditch from 1971 to 1982, therefore, Linear Best Fits do not include these samples.

3) ** Robinson Pond - apparent gravel trap

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FIGURE 5.2-7
SP-G2 TASK 2
BULK SUBSURFACE D50 -
DUNE AND TROUGH
COMPARISON

Prepared by:
JHM -- DWR

Date
8/10/ 04

Filename
Figure 5.2-7.dwg

Figure 5.2-8. Bulk Gravel Subsurface Dg – Dune and Trough Comparison

FIGURE 5.2-8
SP-G2 TASK2
BULK SUBSURFACE Dg -
DUNE AND TROUGH
COMPARISON BY RIVER MILE

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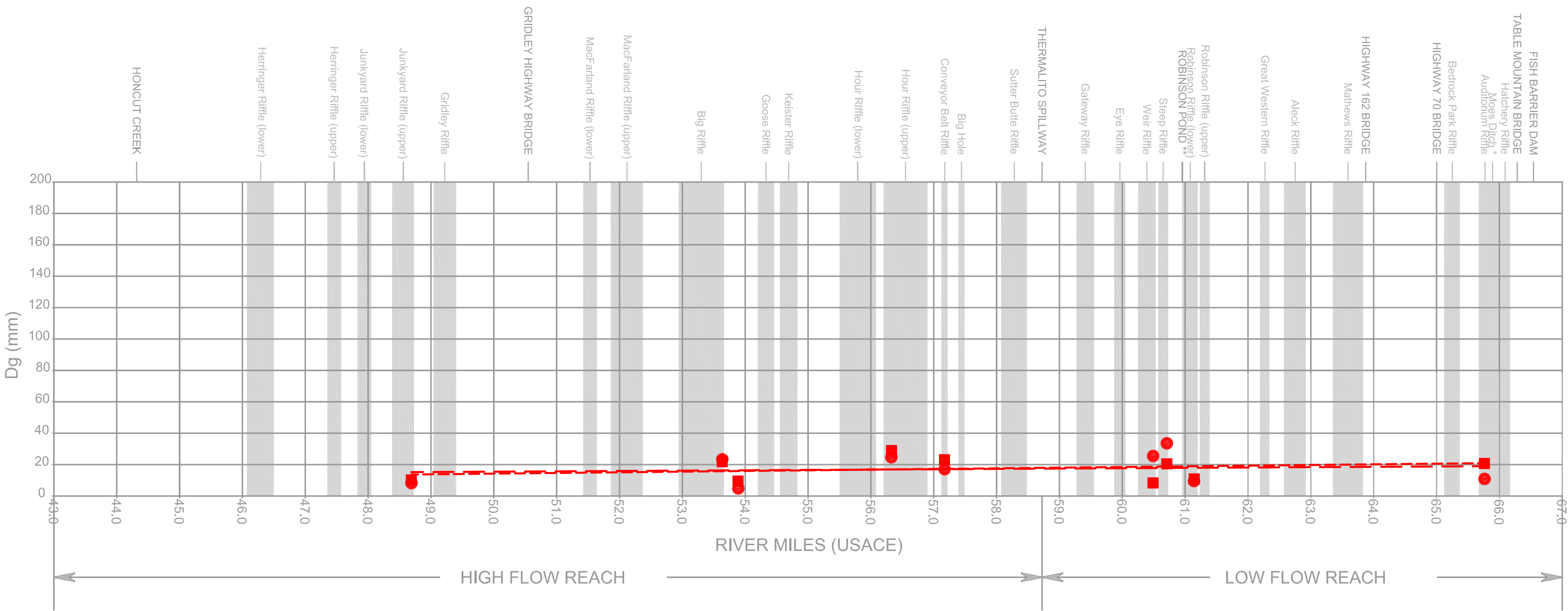
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- Dune Dg
- Trough Dg
— — Dune Dg Linear Best Fit Line
- - - Trough Dg Linear Best Fit Line

NOTES
1) River miles based on USACE 1997 river center line. 0.0 = Feather
   River intersection with Sacramento River.
2) * Spawning gravel injection at Moe's Ditch from 1971 to 1982,
   therefore, Linear Best Fits do not include these samples.
3) ** Robinson Pond - apparent gravel trap

Dg (mm)

RIVER MILES (USACE)

HIGH FLOW REACH   LOW FLOW REACH

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Filename: Figure 5.2-8.dwg

Samples were taken from tailing piles for analysis to determine similarity with riffle gravel size. The sampling results are shown in Table 5.2-5.

5.2.5.1 Armoring

Most of the large depositional features found in this reach are relict structures dating back to before the completion of Oroville Dam in 1967. Pre-Project flood flows would scour the channel, islands, and point bars down to a coarse surface consisting of cobbles and boulders. More moderate flows would then transport in finer sediments and sculpture the depositional features. These moderate flows would deposit a layer of gravel on islands, riffles, and point bars.

Under the post-Oroville Dam hydraulic regime, if undisturbed, point bars and islands would reduce their interaction with the river. Under normal post dam flood flows, these depositional features would not erode and no gravel would be available to deposit. The features generally are armored with sediment that is too coarse for the present river to transport. Record flood flows, such as the January 1997 event, however, can mobilize the bed and affect the distribution of depositional features.

The pre-dam riffle-pool-run distribution of macrohabitat is still largely intact, except for some riffle degradation and movement of riffles in a downstream direction. On the Feather River, riffles have become progressively armored. The suitability of salmon spawning habitat is degraded by excessively coarse gravel and cobbles especially in the Low Flow Reach. The altered hydraulic regime resulting from the construction of Oroville Dam has eliminated smaller gravel from these upper spawning riffles. The altered flow regime resulting from reservoir operation, coupled with lack of gravel recruitment enhances the erosive and scouring capacity of the river at these points, thereby removing surface size fractions suitable for spawning. The result is an armored surface layer.
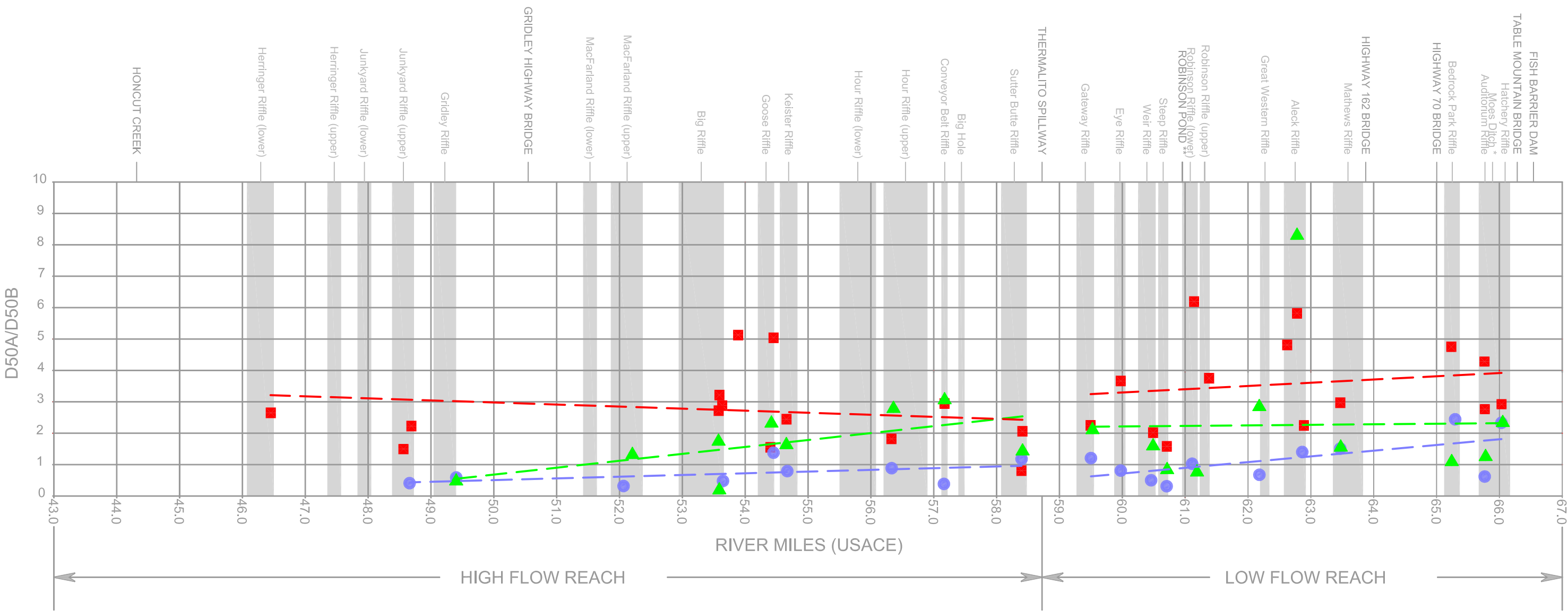
A measure of armoring degree may be determined by dividing the bulk surface D_{50} by the subsurface D_{50}.

Figure 5.2-9 shows the armoring ratios. The armoring effect is easily recognizable when surface and subsurface values are compared. The surface diameters average three to four times the size of subsurface diameters. The armoring ratio may be calculated using either the D_{50}s or the Dgs (Figure 5.2-10) by comparing the surface to subsurface ratios. Both figures show similar trends. Overall, the armoring ratio has increased over the three sampling periods. For example, the average Dg armoring ratio for the Low Flow Reach was about 2.3 in 1982 and 1996 but about 4.5 in 2002-03. For

the High Flow Reach the armoring ration increased from about 1.5 to 3.2 over the same time period.

Figure 5.2-9. Armoring Ratio (D$_{50}$A/D$_{50}$B)

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FIGURE 5.2-9
SP-G2 TASK 2

ARMORING RATIO
(D50A/D50B)

Figure 5.2-10. Armoring Ratio (DgA/DgB)

Figure 5.2-10: Armoring Ratio (DgA/DgB). Oroville Facilities Relicensing, FERC Project No. 2100, SP-G2 Task 2.

LEGEND

- ■ 2003 Bulk Sample Armoring Ratio
- ● 1996 Bulk Sample Armoring Ratio
- ▲ 1982 Bulk Sample Armoring Ratio
- – – 2003 Armoring Ratio Linear Best Fit
- – – 1996 Armoring Ratio Linear Best Fit
- – – 1982 Armoring Ratio Linear Best Fit

NOTES

1) River miles based on USACE 1997 river center line. 0.0 = Feather River intersection with Sacramento River.

2) DgA/DgB is the Dg of the surface sample divided by the Dg of the subsurface sample

3) * Spawning gravel injection at Moe's Ditch from 1971 to 1982, therefore, Linear Best Fits do not include these samples.

4) ** Robinson Pond - apparent gravel trap

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FIGURE 5.2-10
SP-G2 TASK 2

ARMORING RATIO
(DgA/DgB)

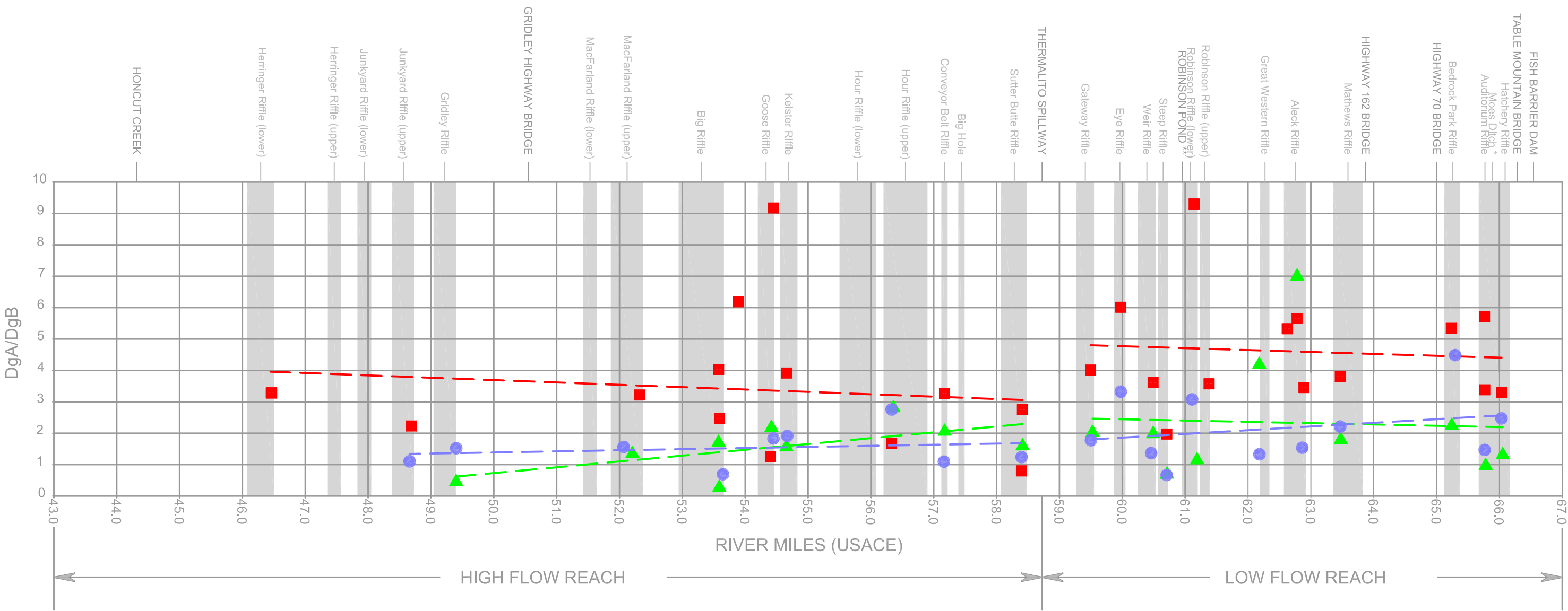Prepared by: GMG -- DWR Date 8/10/ 04 Filename Figure 5.2-10.dwg

Table 5.2-2. Bulk Samples Collected between Thermalito Diversion Dam and Honcut Creek from 2002 to 2003.

River Mile (USACE)	Riffle/Feature	Office Code*	D₅ (mm)	D₁₆ (mm)	D₂₅ (mm)	D₅₀ (mm)	D₇₅ (mm)	D₈₄ (mm)	D₉₅ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
* "Office Code" is defined sequentially by the following: 1) Type of sample --- BS = bulk sample, WS = Wolman sample; 2) Feature --- r = riffle, b = bar, g = glide, t = tailings, blank = unspecified; 3) Location --- t = top (upstream) end of feature, m = middle of feature, b = bottom (downstream) end of feature, blank = unspecified; 4) Number --- consecutive numbering consistent in 1982, 1996, 2002/2003;								5) Local feature --- d = dune, t = trough, e = embedded, blank = unspecified; 6) Year--- year that this site was last sampled --- main years of sampling are 1982, 1996 and 2002/2003, xx means this is the first year sampled; 7) Year--- year that this sample was taken; 8) Vertical stratum sampled --- A = surface, B = subsurface, C = both							
71.500	OROVILLE DAM														
67.128	THERMALITO DIVERSION DAM														
66.541	FISH BARRIER DAM														
66.283	TABLE MOUNTAIN BRIDGE														
66.0336	Hatchery Riffle	BS-rt001-96-2003A	37	67	85	144	211	233	257	125	1.86	83.03	very negative	flat	moderate
66.0336	Hatchery Riffle	BS-rt001-96-2003B	2	9	17	51	110	141	164	36	3.97	66.18	very negative	normal	very poor
66.0336	Hatchery Riffle	BS-rt001-96-2003C	4	23	40	95	169	208	249	69	3.01	92.38	very negative	highly peaked	poor
65.7671	Moes' Ditch	BS-bb002-82-2002A	5	19	28	57	102	122	143	48	2.54	51.63	very negative	normal	poor
65.7671	Moes' Ditch	BS-bb002-82-2002B	1	3	6	19	48	63	99	15	4.27	29.79	negative	normal	very poor
65.7671	Moes' Ditch	BS-bb002-82-2002C	2	7	13	35	71	97	136	25	3.81	45.13	very negative	normal	poor
65.7635	Auditorium Riffle	BS-rt002t-96-2002A	35	107	131	194	251	267	285	169	1.58	80.45	very negative	highly peaked	moderate
65.7635	Auditorium Riffle	BS-rt002t-96-2002B	1	2	5	22	49	64	106	12	5.49	31.12	very negative	normal	very poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D_5 (mm)	D_{16} (mm)	D_{25} (mm)	D_{50} (mm)	D_{75} (mm)	D_{84} (mm)	D_{95} (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
65.7635	Auditorium Riffle	BS-rt002t-96-2002C	1	9	19	75	186	228	273	44	5.16	109.49	very negative	normal	very poor
65.7626	Auditorium Riffle	BS-rt002dt-96-2002A	18	36	56	117	186	228	273	90	2.52	95.81	very negative	normal	poor
65.7626	Auditorium Riffle	BS-rt002dt-96-2002B	1	3	8	27	56	70	135	16	4.48	33.36	very negative	normal	very poor
65.7626	Auditorium Riffle	BS-rt002dt-96-2002C	2	11	21	56	127	163	254	43	3.78	75.72	negative	highly peaked	very poor
65.7616	Auditorium Riffle	BS-rt002d-96-2002A	16	29	35	65	109	126	145	60	2.09	48.52	negative	flat	poor
65.7616	Auditorium Riffle	BS-rt002d-96-2002B	1	6	12	31	63	75	154	22	3.46	34.54	negative	highly peaked	poor
65.7616	Auditorium Riffle	BS-rt002d-96-2002C	3	14	22	45	85	114	147	40	2.87	50.28	negative	highly peaked	poor
65.2340	Bedrock Park Riffle	BS-gm003-82-2003A	23	87	128	194	233	244	255	146	1.67	78.31	very negative	very highly peaked	moderate
65.2340	Bedrock Park Riffle	BS-gm003-82-2003B	1	6	12	37	91	130	176	27	4.77	62.15	negative	normal	very poor
65.2340	Bedrock Park Riffle	BS-gm003-82-2003C	2	15	31	109	197	222	249	58	3.86	103.66	very negative	normal	very poor
65.002	HIGHWAY 70 BRIDGE														
64.2682	River Run Park Pool	BS-pb001-xx-2003A	16	29	36	61	87	113	141	57	1.97	41.82	negative	normal	moderate
63.872	HIGHWAY 162 BRIDGE														
63.4679	Mathews Riffle	BS-rt004-96-2002A	27	60	76	127	166	192	220	108	1.78	65.85	very negative	normal	moderate
63.4679	Mathews Riffle	BS-rt004-96-2002B	1	5	11	38	109	135	168	27	4.97	64.89	negative	flat	very poor
63.4679	Mathews Riffle	BS-rt004-96-2002C	3	15	30	90	143	168	213	50	3.38	76.52	very negative	highly peaked	poor
62.8887	Aleck Riffle	BS-rt005-96-2003A	17	42	62	134	280	330	384	118	2.80	143.68	negative	flat	poor

River Mile (USACE)	Riffle/Feature	Office Code*	D_5 (mm)	D_{16} (mm)	D_{25} (mm)	D_{50} (mm)	D_{75} (mm)	D_{84} (mm)	D_{95} (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
62.8887	Aleck Riffle	BS-rt005-96-2003B	2	6	16	61	131	171	261	33	5.23	82.55	very negative	normal	very poor
62.8887	Aleck Riffle	BS-rt005-96-2003C	3	18	36	87	209	287	371	71	4.02	134.58	negative	highly peaked	very poor
62.7793	Aleck Riffle	BS-gt005-82-2003A	25	60	80	150	212	230	249	117	1.96	85.12	very negative	normal	moderate
62.7793	Aleck Riffle	BS-gt005-82-2003B	1	4	8	28	67	99	170	20	4.92	47.58	negative	normal	very poor
62.7793	Aleck Riffle	BS-gt005-82-2003C	2	10	22	72	167	202	241	46	4.39	95.88	very negative	normal	very poor
62.6229	Aleck Tailings	BS-TP-bm009-xx-2003A	6	35	60	118	165	189	215	81	2.33	76.96	very negative	highly peaked	poor
62.6229	Aleck Tailings	BS-TP-bm009-xx-2003B	1	2	4	23	79	127	161	16	8.06	62.45	negative	flat	very poor
62.6229	Aleck Tailings	BS-TP-bm009-xx-2003C	1	5	14	68	140	169	209	29	5.81	81.79	very negative	normal	very poor
61.3798	Robinson Riffle (upper)	BS-rt006-xx-2003A	14	34	52	94	135	146	181	71	2.06	55.79	very negative	highly peaked	poor
61.3798	Robinson Riffle (upper)	BS-rt006-xx-2003B	2	6	9	25	57	70	139	20	3.54	32.29	negative	normal	poor
61.3798	Robinson Riffle (upper)	BS-rt006-xx-2003C	3	10	18	54	106	131	168	36	3.64	60.39	very negative	normal	poor
61.1432	Robinson Riffle (lower)	BS-bt007d-xx-2003A	32	115	146	208	246	257	268	172	1.49	70.72	very negative	very highly peaked	moderate
61.1432	Robinson Riffle (lower)	BS-bt007d-xx-2003B	0	1	4	24	68	99	149	12	8.58	48.88	very negative	flat	very poor
61.1432	Robinson Riffle (lower)	BS-bt007d-xx-2003C	1	7	18	104	201	229	260	39	5.82	111.31	very negative	normal	very poor
61.1415	Robinson Riffle (lower)	BS-bt007dt-xx-2003A	7	44	70	142	215	238	263	102	2.34	97.29	very negative	highly peaked	poor
61.1415	Robinson Riffle (lower)	BS-bt007dt-xx-2003B	0	1	4	23	62	85	147	11	7.93	41.65	very negative	normal	very poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D_5 (mm)	D_{16} (mm)	D_{25} (mm)	D_{50} (mm)	D_{75} (mm)	D_{84} (mm)	D_{95} (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
61.1415	Robinson Riffle (lower)	BS-bt007dt-xx-2003C	1	6	16	65	151	199	251	34	5.89	96.42	very negative	normal	very poor
61.1398	Robinson Riffle (lower)	BS-bt007t-xx-2003A	3	23	41	86	141	165	223	61	2.68	70.80	very negative	highly peaked	poor
61.1398	Robinson Riffle (lower)	BS-bt007t-xx-2003B	0	1	5	23	57	73	144	10	7.36	35.85	very negative	normal	very poor
61.1398	Robinson Riffle (lower)	BS-bt007t-xx-2003C	1	5	13	49	109	138	206	26	5.35	66.37	very negative	highly peaked	very poor
60.7084	Steep Riffle	BS-rt008t-96-2003A	12	33	49	86	127	138	151	67	2.06	52.86	very negative	highly peaked	poor
60.7084	Steep Riffle	BS-rt008t-96-2003B	2	11	18	39	76	116	174	36	3.20	52.35	negative	highly peaked	poor
60.7084	Steep Riffle	BS-rt008t-96-2003C	4	17	28	63	113	132	157	47	2.79	57.58	very negative	normal	poor
60.7077	Steep Riffle	BS-rt008dt-96-2003A	11	29	41	67	103	124	146	60	2.05	47.17	negative	highly peaked	poor
60.7077	Steep Riffle	BS-rt008dt-96-2003B	1	9	17	38	70	91	146	29	3.19	41.15	very negative	highly peaked	poor
60.7077	Steep Riffle	BS-rt008dt-96-2003C	2	16	27	55	83	113	146	43	2.65	48.60	very negative	highly peaked	poor
60.7070	Steep Riffle	BS-rt008d-96-2003A	11	27	36	59	72	76	130	45	1.67	24.46	very negative	highly peaked	moderate
60.7070	Steep Riffle	BS-rt008d-96-2003B	1	6	16	37	65	73	124	22	3.40	33.57	very negative	highly peaked	poor
60.7070	Steep Riffle	BS-rt008d-96-2003C	2	15	25	50	70	75	127	34	2.24	30.10	very negative	very highly peaked	poor
60.4897	Weir Riffle	BS-bm009t-82-2003A	10	32	51	95	128	138	148	67	2.07	52.85	very negative	highly peaked	poor
60.4897	Weir Riffle	BS-bm009t-82-2003B	1	7	15	45	88	113	141	28	4.05	53.09	very negative	highly peaked	very poor
60.4897	Weir Riffle	BS-bm009t-82-2003C	2	15	28	68	115	130	146	44	2.95	57.39	very negative	highly peaked	poor

River Mile (USACE)	Riffle/Feature	Office Code*	D_5 (mm)	D_{16} (mm)	D_{25} (mm)	D_{50} (mm)	D_{75} (mm)	D_{84} (mm)	D_{95} (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
60.4889	Weir Riffle	BS-bm009dt-82-2003A	9	24	33	62	101	121	143	54	2.24	48.42	negative	normal	poor
60.4889	Weir Riffle	BS-bm009dt-82-2003B	1	2	9	30	63	75	129	14	5.49	36.43	very negative	normal	very poor
60.4889	Weir Riffle	BS-bm009dt-82-2003C	1	10	19	45	76	106	139	32	3.33	48.26	very negative	highly peaked	poor
60.4880	Weir Riffle	BS-bm009d-82-2003A	7	20	28	46	66	72	112	38	1.89	26.00	very negative	highly peaked	poor
60.4880	Weir Riffle	BS-bm009d-82-2003B	1	1	4	22	39	55	72	9	6.06	26.68	very negative	flat	very poor
60.4880	Weir Riffle	BS-bm009d-82-2003C	1	6	15	33	58	67	85	20	3.30	30.34	very negative	highly peaked	poor
59.9736	Eye Riffle	BS-rm021-96-2003A	11	38	58	106	151	172	196	81	2.12	66.82	very negative	highly peaked	poor
59.9736	Eye Riffle	BS-rm021-96-2003B	0	2	5	28	77	113	151	14	7.78	55.32	very negative	flat	very poor
59.9736	Eye Riffle	BS-rm021-96-2003C	1	7	19	65	128	149	188	32	4.68	70.87	very negative	highly peaked	very poor
59.4939	Gateway Riffle	BS-rt010-96-2003A	25	52	67	112	148	164	187	92	1.78	56.09	very negative	normal	moderate
59.4939	Gateway Riffle	BS-rt010-96-2003B	1	4	13	47	85	114	145	23	5.04	54.63	very negative	normal	very poor
59.4939	Gateway Riffle	BS-rt010-96-2003C	2	18	34	73	128	145	178	51	2.86	63.64	very negative	highly peaked	poor
58.722	THERMALITO SPILLWAY														
58.4097	Sutter Butte Riffle	BS-rt011-82-2003A	20	36	47	71	114	130	149	68	1.91	47.33	negative	normal	moderate
58.4097	Sutter Butte Riffle	BS-rt011-82-2003B	1	5	10	34	91	119	150	24	5.00	57.17	very negative	normal	very poor
58.4097	Sutter Butte Riffle	BS-rt011-82-2003C	2	14	25	59	105	126	149	42	3.01	55.98	very negative	highly peaked	poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D$_5$ (mm)	D$_{16}$ (mm)	D$_{25}$ (mm)	D$_{50}$ (mm)	D$_{75}$ (mm)	D$_{84}$ (mm)	D$_{95}$ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
58.3941	Sutter Butte Riffle	BS-rt011-96-2003A	5	17	29	56	74	95	136	41	2.35	39.01	very negative	highly peaked	poor
58.3941	Sutter Butte Riffle	BS-rt011-96-2003B	3	15	27	66	133	164	228	50	3.27	74.46	very negative	highly peaked	poor
58.3941	Sutter Butte Riffle	BS-rt011-96-2003C	4	16	28	59	100	131	198	46	2.83	57.19	very negative	highly peaked	poor
57.1715	Conveyor Belt Riffle	BS-rt012t-82-2003A	16	47	67	125	177	200	225	97	2.06	76.40	very negative	highly peaked	poor
57.1715	Conveyor Belt Riffle	BS-rt012t-82-2003B	2	5	8	17	40	62	114	18	3.40	28.38	symmetrical	normal	poor
57.1715	Conveyor Belt Riffle	BS-rt012t-82-2003C	3	9	15	54	128	157	212	37	4.23	74.22	negative	flat	poor
57.1707	Conveyor Belt Riffle	BS-rt012dt-82-2003A	12	32	45	72	133	157	212	71	2.22	62.71	negative	normal	poor
57.1707	Conveyor Belt Riffle	BS-rt012dt-82-2003B	2	5	9	25	64	85	141	21	4.00	39.92	negative	normal	poor
57.1707	Conveyor Belt Riffle	BS-rt012dt-82-2003C	2	10	17	52	100	132	194	35	3.72	61.16	very negative	normal	poor
57.1699	Conveyor Belt Riffle	BS-rt012d-xx-2003A	9	26	35	58	73	89	134	48	1.86	31.47	very negative	highly peaked	poor
57.1699	Conveyor Belt Riffle	BS-rt012d-xx-2003B	1	5	12	39	79	114	153	25	4.64	54.51	very negative	normal	very poor
57.1699	Conveyor Belt Riffle	BS-rt012d-xx-2003C	2	12	22	52	74	102	144	35	2.88	44.96	very negative	highly peaked	poor
56.3269	Hour Riffle (upper)	BS-rm013d-96-2003A	3	10	18	56	107	129	153	36	3.58	59.32	very negative	normal	poor
56.3269	Hour Riffle (upper)	BS-rm013d-96-2003B	2	7	13	49	111	135	177	32	4.29	63.89	very negative	flat	very poor
56.3269	Hour Riffle (upper)	BS-rm013d-96-2003C	2	8	16	53	109	132	169	33	3.94	61.63	very negative	normal	poor
56.3256	Hour Riffle (upper)	BS-rm013dt-96-2003A	3	13	26	74	142	171	212	48	3.56	78.54	very negative	normal	poor

River Mile (USACE)	Riffle/Feature	Office Code*	D₅ (mm)	D₁₆ (mm)	D₂₅ (mm)	D₅₀ (mm)	D₇₅ (mm)	D₈₄ (mm)	D₉₅ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
56.3256	Hour Riffle (upper)	BS-rm013dt-96-2003B	1	6	11	41	104	136	182	29	4.73	64.95	very negative	normal	very poor
56.3256	Hour Riffle (upper)	BS-rm013dt-96-2003C	2	8	16	59	127	152	206	36	4.25	71.59	very negative	normal	very poor
56.3244	Hour Riffle (upper)	BS-rm013t-96-2003A	4	18	37	115	179	199	220	60	3.32	90.29	very negative	normal	poor
56.3244	Hour Riffle (upper)	BS-rm013t-96-2003B	1	5	9	35	94	138	184	25	5.43	66.61	negative	normal	very poor
56.3244	Hour Riffle (upper)	BS-rm013t-96-2003C	1	8	17	65	150	181	215	39	4.67	86.26	very negative	normal	very poor
54.6562	Keister Riffle	BS-rt014-82-2003A	18	40	55	88	150	180	214	85	2.13	70.25	negative	normal	poor
54.6562	Keister Riffle	BS-rt014-82-2003B	1	5	11	35	72	99	137	22	4.49	47.21	very negative	normal	very poor
54.6562	Keister Riffle	BS-rt014-82-2003C	2	14	27	62	117	142	198	45	3.16	64.01	very negative	highly peaked	poor
54.4504	Goose Riffle	BS-bb015-96-2003A	9	31	40	65	97	121	146	61	1.99	45.00	negative	highly peaked	poor
54.4504	Goose Riffle	BS-bb015-96-2003B	0	1	2	12	36	55	95	6	8.54	27.03	negative	flat	very poor
54.4504	Goose Riffle	BS-bb015-96-2003C	0	3	9	37	70	91	137	16	5.53	44.11	very negative	highly peaked	very poor
54.3992	Goose Riffle	BS-rt015-82-2003A	1	9	17	35	59	67	76	24	2.74	29.06	very negative	highly peaked	poor
54.3992	Goose Riffle	BS-rt015-82-2003B	1	8	11	23	37	53	73	21	2.58	22.59	negative	very highly peaked	poor
54.3992	Goose Riffle	BS-rt015-82-2003C	1	8	13	29	51	62	75	23	2.75	27.10	very negative	highly peaked	poor
53.8887	Goose Backwater Tailings	BS-TP-bm004t-xx-2003A	1	15	30	68	122	140	168	45	3.10	62.95	very negative	very highly peaked	very poor
53.8887	Goose Backwater Tailings	BS-TP-bm004t-xx-2003B	0	1	2	14	30	36	66	5	7.15	17.86	very negative	normal	very poor
53.8887	Goose Backwater Tailings	BS-TP-bm004t-xx-2003C	0	2	8	30	72	106	152	16	6.78	51.84	very negative	highly peaked	very poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D$_5$ (mm)	D$_{16}$ (mm)	D$_{25}$ (mm)	D$_{50}$ (mm)	D$_{75}$ (mm)	D$_{84}$ (mm)	D$_{95}$ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
53.8866	Goose Backwater Tailings	BS-TP-bm004dt-xx-2003A	1	15	31	74	126	141	166	46	3.07	63.15	very negative	highly peaked	poor
53.8866	Goose Backwater Tailings	BS-TP-bm004dt-xx-2003B	0	1	4	15	33	41	69	7	5.88	20.13	very negative	normal	very poor
53.8866	Goose Backwater Tailings	BS-TP-bm004dt-xx-2003C	0	4	9	32	77	112	150	21	5.48	54.31	very negative	highly peaked	very poor
53.8844	Goose Backwater Tailings	BS-TP-bm004d-xx-2003A	2	15	33	86	130	142	161	47	3.03	63.29	very negative	highly peaked	poor
53.8844	Goose Backwater Tailings	BS-TP-bm004d-xx-2003B	0	2	5	17	35	49	71	10	4.81	23.42	very negative	normal	very poor
53.8844	Goose Backwater Tailings	BS-TP-bm004d-xx-2003C	1	10	21	70	156	164	174	40	4.15	77.43	very negative	normal	very poor
53.6349	Big Riffle	BS-rt017t-96-2003A	14	40	67	115	144	154	202	79	1.96	57.10	very negative	highly peaked	poor
53.6349	Big Riffle	BS-rt017t-96-2003B	1	5	9	32	74	132	197	24	5.40	63.58	negative	normal	very poor
53.6349	Big Riffle	BS-rt017t-96-2003C	2	10	22	71	132	150	200	40	3.78	69.74	very negative	normal	very poor
53.6335	Big Riffle	BS-rt017dt-96-2003A	13	35	52	89	131	143	180	71	2.03	54.20	very negative	highly peaked	poor
53.6335	Big Riffle	BS-rt017dt-96-2003B	1	6	9	31	69	103	175	24	4.30	48.64	negative	normal	very poor
53.6335	Big Riffle	BS-rt017dt-96-2003C	2	11	21	60	113	134	178	39	3.44	61.53	very negative	normal	poor
53.6320	Big Riffle	BS-rt017d-96-2003A	12	32	44	70	111	127	145	63	2.01	47.79	negative	highly peaked	poor
53.6320	Big Riffle	BS-rt017d-96-2003B	2	7	11	30	65	82	137	23	3.53	37.88	negative	normal	poor
53.6320	Big Riffle	BS-rt017d-96-2003C	3	12	20	53	89	115	142	37	3.08	51.21	very negative	normal	poor
53.5885	Big Riffle	BS-bt017-82-2003A	2	18	39	89	134	147	186	51	2.86	64.35	very negative	highly peaked	poor
53.5885	Big Riffle	BS-bt017-82-2003B	1	4	6	28	84	122	162	22	5.46	58.79	negative	flat	very poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D_5 (mm)	D_{16} (mm)	D_{25} (mm)	D_{50} (mm)	D_{75} (mm)	D_{84} (mm)	D_{95} (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
53.5885	Big Riffle	BS-bt017-82-2003C	1	5	13	59	119	140	181	27	5.08	67.05	very negative	flat	very poor
53.5768	Big Riffle	BS-bt016-82-2003A	18	47	62	100	136	146	164	83	1.77	49.72	very negative	highly peaked	moderate
53.5768	Big Riffle	BS-bt016-82-2003B	1	4	9	35	71	103	152	20	5.00	49.24	very negative	normal	very poor
53.5768	Big Riffle	BS-bt016-82-2003C	2	12	26	66	118	136	160	40	3.44	62.48	very negative	highly peaked	poor
52.3189	MacFarland Riffle (upper)	BS-rt018-82-2003A	7	27	38	70	115	132	150	59	2.22	52.57	very negative	highly peaked	poor
52.3189	MacFarland Riffle (upper)	BS-rt018-82-2003B	1	4	8	28	61	73	126	17	4.20	34.62	very negative	normal	very poor
52.3189	MacFarland Riffle (upper)	BS-rt018-82-2003C	2	9	18	49	87	114	144	32	3.62	52.78	very negative	highly peaked	poor
50.545	GRIDLEY HIGHWAY BRIDGE														
48.6887	Junkyard Riffle (upper)	BS-rt020t-96-2003A	2	9	16	37	62	69	89	25	2.75	29.94	very negative	highly peaked	poor
48.6887	Junkyard Riffle (upper)	BS-rt020t-96-2003B	1	2	4	14	35	52	75	9	5.83	25.26	negative	flat	very poor
48.6887	Junkyard Riffle (upper)	BS-rt020t-96-2003C	1	4	8	25	53	64	79	15	4.23	30.24	very negative	normal	very poor
48.6875	Junkyard Riffle (upper)	BS-rt020dt-96-2003A	1	7	14	34	59	67	76	22	3.01	29.97	very negative	highly peaked	poor
48.6875	Junkyard Riffle (upper)	BS-rt020dt-96-2003B	1	2	4	16	39	58	92	10	5.81	28.17	negative	normal	very poor
48.6875	Junkyard Riffle (upper)	BS-rt020dt-96-2003C	1	3	7	25	53	64	84	15	4.38	30.45	very negative	normal	very poor
48.6864	Junkyard Riffle (upper)	BS-rt020d-96-2003A	1	5	11	32	57	66	75	19	3.48	30.05	very negative	highly peaked	poor
48.6864	Junkyard Riffle	BS-rt020d-96-2003B	1	2	5	18	46	63	105	11	5.68	30.48	negative	normal	very poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D_5 (mm)	D_{16} (mm)	D_{25} (mm)	D_{50} (mm)	D_{75} (mm)	D_{84} (mm)	D_{95} (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
	(upper)														
48.6864	Junkyard Riffle (upper)	BS-rt020d-96-2003C	1	3	7	26	53	64	88	14	4.58	30.69	very negative	normal	very poor
46.4615	Herringer Riffle (lower)	BS-bb023-xx-2003A	1	8	15	35	62	71	115	24	2.90	31.15	very negative	highly peaked	poor
46.4615	Herringer Riffle (lower)	BS-bb023-xx-2003B	0	1	2	10	29	38	67	6	6.15	18.36	negative	flat	very poor
46.4615	Herringer Riffle (lower)	BS-bb023-xx-2003C	1	2	5	21	47	61	86	10	5.86	29.84	very negative	normal	very poor
46.4538	Herringer Riffle (lower)	BS-bb022/023-xx-2003A	1	7	13	32	56	66	86	22	3.01	29.42	very negative	highly peaked	poor
46.4538	Herringer Riffle (lower)	BS-bb022/023-xx-2003B	1	1	2	11	30	38	66	6	5.94	18.43	negative	flat	very poor
46.4538	Herringer Riffle (lower)	BS-bb022/023-xx-2003C	1	2	6	20	42	58	74	11	5.22	27.72	very negative	normal	very poor
46.4462	Herringer Riffle (lower)	BS-bb022-xx-2003A	2	6	11	28	50	61	73	20	3.07	27.17	very negative	normal	poor
46.4462	Herringer Riffle (lower)	BS-bb022-xx-2003B	1	1	3	13	31	38	66	7	5.73	18.47	very negative	flat	very poor
46.4462	Herringer Riffle (lower)	BS-bb022-xx-2003C	1	2	6	19	38	53	71	11	4.67	25.48	very negative	normal	very poor
44.315	HONCUT CREEK														

Table 5.2-3. Bulk Samples Collected between Thermalito Diversion Dam and Honcut Creek in 1996.

River Mile (USACE)	Riffle/Feature	Office Code*	D$_5$ (mm)	D$_{16}$ (mm)	D$_{25}$ (mm)	D$_{50}$ (mm)	D$_{75}$ (mm)	D$_{84}$ (mm)	D$_{95}$ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
* "Office Code" is defined sequentially by the following: 1) Type of sample --- BS = bulk sample, WS = Wolman sample; 2) Feature --- r = riffle, b = bar, g = glide, t = tailings, blank = unspecified; 3) Location --- t = top (upstream) end of feature, m = middle of feature, b = bottom (downstream) end of feature, blank = unspecified; 4) Number --- consecutive numbering consistent in 1982, 1996, 2002/2003;						5) Local feature --- d = dune, t = trough, e = embedded, blank = unspecified; 6) Year--- year that this site was last sampled --- main years of sampling are 1982, 1996 and 2002/2003, xx means this is the first year sampled; 7) Year--- year that this sample was taken; 8) Vertical stratum sampled --- A = surface, B = subsurface, C = both									
71.50	OROVILLE DAM														
67.13	THERMALITO DIVERSION DAM														
66.54	FISH BARRIER DAM														
66.28	TABLE MOUNTAIN BRIDGE														
66.03	Hatchery Riffle	BS-rt001-xx-1996A	72	106	125	155	198	210	223	149	1.4	51.9	negative	normal	well
66.03	Hatchery Riffle	BS-rt001-xx-1996B	7	20	31	74	133	149	182	55	2.7	64.5	very negative	normal	poor
66.03	Hatchery Riffle	BS-rt001-xx-1996C	13	37	65	125	174	195	219	85	2.3	79.0	very negative	highly peaked	poor
65.77	Moes' Ditch	BS-rt002-xx-1996A	19	25	31	43	68	75	128	44	1.7	25.1	symmetrical	normal	moderate
65.77	Moes' Ditch	BS-rt002-xx-1996B	6	13	18	36	61	69	86	30	2.3	27.7	negative	flat	poor
65.77	Moes' Ditch	BS-rt002-xx-1996C	9	18	24	39	65	72	116	36	2.0	27.2	negative	normal	poor
65.29	Bedrock Park Riffle	BS-bm003-xx-1996A	67	108	127	166	217	232	247	158	1.5	62.1	negative	normal	moderately well
65.29	Bedrock Park Riffle	BS-bm003-xx-1996B	1	7	14	46	119	153	171	33	4.7	73.2	very negative	normal	very poor
65.29	Bedrock Park Riffle	BS-bm003-xx-1996C	3	19	42	119	188	214	242	64	3.3	97.4	very negative	highly peaked	poor
65.00	HIGHWAY 70 BRIDGE														
63.87	HIGHWAY 162 BRIDGE														
63.47	Mathews Riffle	BS-rt004-82-1996A	35	61	72	112	139	147	163	95	1.5	42.6	very negative	normal	moderately well

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River Mile (USACE)	Riffle/Feature	Office Code*	D$_5$ (mm)	D$_{16}$ (mm)	D$_{25}$ (mm)	D$_{50}$ (mm)	D$_{75}$ (mm)	D$_{84}$ (mm)	D$_{95}$ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
63.47	Mathews Riffle	BS-rt004-82-1996B	2	13	23	57	109	132	156	42	3.2	59.4	very negative	highly peaked	poor
63.47	Mathews Riffle	BS-rt004-82-1996C	7	28	44	84	129	142	162	63	2.3	57.1	very negative	highly peaked	poor
62.86	Aleck Riffle	BS-bt005-xx-1996A	19	33	39	99	135	145	158	69	2.1	56.3	very negative	flat	poor
62.86	Aleck Riffle	BS-bt005-xx-1996B	2	17	27	52	80	108	139	43	2.5	45.5	very negative	very highly peaked	poor
62.86	Aleck Riffle	BS-bt005-xx-1996C	10	25	33	68	117	134	152	58	2.3	54.4	very negative	normal	poor
62.18	Great Western Riffle	BS-bt006-82-1996A	14	34	52	94	135	146	181	71	2.1	55.8	very negative	highly peaked	poor
62.18	Great Western Riffle	BS-bt006-82-1996B	2	6	9	25	57	70	139	20	3.5	32.3	negative	normal	poor
62.18	Great Western Riffle	BS-bt006-82-1996C	3	10	18	54	106	131	152	36	3.6	60.4	very negative	flat	poor
61.11	Robinson Riffle (lower)	BS-bm007-xx-1996A	8	23	37	68	111	127	145	54	2.4	52.3	very negative	normal	poor
61.11	Robinson Riffle (lower)	BS-bm007-xx-1996B	1	4	9	30	60	70	128	17	4.2	33.2	very negative	highly peaked	very poor
61.11	Robinson Riffle (lower)	BS-bm007-xx-1996C	1	9	18	49	78	109	142	32	3.4	49.7	very negative	highly peaked	poor
60.71	Steep Riffle	BS-rt008-82-1996A	1	5	9	19	35	43	66	15	2.9	18.7	very negative	highly peaked	poor
60.71	Steep Riffle	BS-rt008-82-1996B	1	2	6	18	35	50	78	10	4.9	24.0	very negative	highly peaked	very poor
60.71	Steep Riffle	BS-rt008-82-1996C	1	3	8	19	35	46	71	13	3.7	21.3	very negative	highly peaked	poor
60.46	Weir Riffle	BS-bb009-xx-1996A	1	11	17	33	98	119	143	36	3.4	54.4	negative	highly peaked	poor
60.46	Weir Riffle	BS-bb009-xx-1996B	1	5	14	40	88	124	162	26	4.8	59.2	very negative	highly peaked	very poor
60.46	Weir Riffle	BS-bb009-xx-1996C	1	8	16	35	94	121	150	31	3.9	56.5	negative	highly peaked	very poor
59.97	Eye Riffle	BS-rm021-xx-1996A	1	17	31	56	73	86	133	39	2.2	34.2			
59.97	Eye Riffle	BS-rm021-xx-1996B	1	2	10	39	69	79	131	12	6.9	38.8			
59.97	Eye Riffle	BS-rm021-xx-1996C	1	6	24	51	71	83	132	22	3.8	38.8			
59.50	Gateway Riffle	BS-rt010-82-1996A	1	14	29	74	124	138	157	44	3.2	62.1	very negative	highly peaked	poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D5 (mm)	D16 (mm)	D25 (mm)	D50 (mm)	D75 (mm)	D84 (mm)	D95 (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
59.50	Gateway Riffle	BS-rt010-82-1996B	1	3	10	54	144	164	183	24	6.9	80.4	very negative	flat	very poor
59.50	Gateway Riffle	BS-rt010-82-1996C	1	7	17	68	130	149	178	33	4.5	70.8	very negative	normal	very poor
58.72	THERMALITO SPILLWAY														
58.40	Sutter Butte Riffle	BS-rt011-82-1996A	1	14	30	72	119	133	149	44	3.0	59.5	very negative	highly peaked	poor
58.40	Sutter Butte Riffle	BS-rt011-82-1996B	1	7	16	59	135	169	220	34	4.9	81.0	very negative	normal	very poor
58.40	Sutter Butte Riffle	BS-rt011-82-1996C	1	9	21	67	124	143	201	37	3.9	66.6	very negative	highly peaked	very poor
57.16	Conveyor Belt Riffle	BS-rm012-82-1996A	2	6	9	24	59	74	127	21	3.6	34.0	negative	normal	poor
57.16	Conveyor Belt Riffle	BS-rm012-82-1996B	1	6	9	18	43	63	113	19	3.2	28.5	negative	highly peaked	poor
57.16	Conveyor Belt Riffle	BS-rm012-82-1996C	1	6	9	20	52	69	122	20	3.4	31.6	negative	normal	poor
56.33	Hour Riffle (upper)	BS-bm013-82-1996A	1	7	16	55	104	127	152	30	4.2	59.9	very negative	highly peaked	very poor
56.33	Hour Riffle (upper)	BS-bm013-82-1996B	1	2	5	17	46	65	115	11	5.9	31.3	negative	normal	very poor
56.33	Hour Riffle (upper)	BS-bm013-82-1996C	1	3	8	31	72	102	143	18	5.6	49.5	very negative	normal	very poor
54.67	Keister Riffle	BS-rt014-82-1996A	1	7	14	47	82	109	140	28	3.9	51.2	very negative	highly peaked	very poor
54.67	Keister Riffle	BS-rt014-82-1996B	1	3	7	25	51	65	104	14	4.5	30.8	very negative	normal	very poor
54.67	Keister Riffle	BS-rt014-82-1996C	1	4	9	33	67	82	132	19	4.3	38.9	very negative	normal	very poor
54.45	Goose Riffle	BS-bb015-xx-1996A	5	23	42	76	120	133	147	56	2.4	54.8	very negative	highly peaked	poor
54.45	Goose Riffle	BS-bb015-xx-1996B	1	8	16	50	90	115	141	30	3.8	53.3	very negative	highly peaked	very poor
54.45	Goose Riffle	BS-bb015-xx-1996C	2	13	26	64	109	126	145	41	3.1	56.5	very negative	highly peaked	poor
53.65	Big Riffle	BS-bt017-82-1996A	1	4	12	29	48	64	105	16	4.1	30.0	very negative	very highly peaked	very poor
53.65	Big Riffle	BS-bt017-82-1996B	1	6	11	31	65	83	132	22	3.8	38.8	very negative	highly peaked	very poor
53.65	Big Riffle	BS-bt017-82-1996C	1	5	11	30	57	71	124	19	3.9	33.3	very negative	highly peaked	very poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D$_5$ (mm)	D$_{16}$ (mm)	D$_{25}$ (mm)	D$_{50}$ (mm)	D$_{75}$ (mm)	D$_{84}$ (mm)	D$_{95}$ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
52.06	MacFarland Riffle (upper)	BS-bm018-xx-1996A	1	3	8	18	35	49	70	13	3.8	22.7	very negative	highly peaked	very poor
52.06	MacFarland Riffle (upper)	BS-bm018-xx-1996B	1	2	4	14	32	38	65	8	4.8	18.1	very negative	normal	very poor
52.06	MacFarland Riffle (upper)	BS-bm018-xx-1996C	1	2	5	16	34	44	68	10	4.5	20.8	very negative	normal	very poor
50.55	GRIDLEY HIGHWAY BRIDGE														
49.40	Gridley Riffle	BS-rt019-82-1996A	1	14	21	33	51	64	91	30	2.1	24.9	very negative	very highly peaked	poor
49.40	Gridley Riffle	BS-rt019-82-1996B	1	6	15	31	51	64	98	19	3.4	29.3	very negative	very highly peaked	poor
49.40	Gridley Riffle	BS-rt019-82-1996C	1	10	18	32	51	64	95	25	2.6	27.1	very negative	very highly peaked	poor
48.66	Junkyard Riffle (upper)	BS-bt020-xx-1996A	1	3	7	21	38	54	71	12	4.5	25.5	very negative	highly peaked	very poor
48.66	Junkyard Riffle (upper)	BS-bt020-xx-1996B	1	2	5	16	33	41	67	10	4.1	19.4	very negative	normal	very poor
48.66	Junkyard Riffle (upper)	BS-bt020-xx-1996C	1	3	6	18	36	48	69	11	4.4	22.9	very negative	highly peaked	very poor
44.32	HONCUT CREEK														

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Table 5.2-4. Bulk Samples Collected between Thermalito Diversion Dam and Honcut Creek in 1982.

River Mile (USACE)	Riffle/Feature	Office Code*	D₅ (mm)	D₁₆ (mm)	D₂₅ (mm)	D₅₀ (mm)	D₇₅ (mm)	D₈₄ (mm)	D₉₅ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer)	*Description of Kurtosis --- Frequency Distribution	Description of Sorting
	* "Office Code" is defined sequentially by the following: 1) Type of sample --- BS = bulk sample, WS = Wolman sample; 2) Feature --- r = riffle, b = bar, g = glide, t = tailings, blank = unspecified; 3) Location --- t = top (upstream) end of feature, m = middle of feature, b = bottom (downstream) end of feature, blank = unspecified; 4) Number --- consecutive numbering consistent in 1982, 1996, 2002/2003;					5) Local feature --- d = dune, t = trough, e = embedded, blank = unspecified; 6) Year--- year that this site was last sampled --- main years of sampling are 1982, 1996 and 2002/2003, xx means this is the first year sampled; 7) Year--- year that this sample was taken; 8) Vertical stratum sampled --- A = surface, B = subsurface, C = both							
71.500	OROVILLE DAM														
67.128	THERMALITO DIVERSION DAM														
66.541	FISH BARRIER DAM														
66.283	TABLE MOUNTAIN BRIDGE														
66.0531	Hatchery Riffle	BS-bt001-xx-1982A	1	2	----	14	----	36	47	7.5	4.77	17.21	very skewed towards coarse	----	poor
66.0531	Hatchery Riffle	BS-bt001-xx-1982B	1	2	----	6	----	22	35	5.8	3.82	10.25	symmetrical	----	poor
65.7806	Moes' Ditch	BS-bb002-xx-1982A	1	2	----	10	----	27	38	6.6	4.12	12.71	skewed towards coarse	----	poor
65.7806	Moes' Ditch	BS-bb002-xx-1982B	1	1	----	8	----	37	47	6.8	5.44	17.88	skewed towards coarse	----	very poor
65.2414	Bedrock Park Riffle	BS-gm003-xx-1982A	52	78	----	96	----	112	129	93.5	1.20	17.00	skewed towards coarse	----	very well
65.2414	Bedrock Park Riffle	BS-gm003-xx-1982B	2	16	----	88	----	112	137	41.7	2.69	48.25	very skewed towards coarse	----	poor
65.002	HIGHWAY 70 BRIDGE														

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River Mile (USACE)	Riffle/Feature	Office Code*	D₅ (mm)	D₁₆ (mm)	D₂₅ (mm)	D₅₀ (mm)	D₇₅ (mm)	D₈₄ (mm)	D₉₅ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer)	*Description of Kurtosis --- Frequency Distribution	Description of Sorting
63.872	HIGHWAY 162 BRIDGE														
63.4750	Mathews Riffle	BS-rt004-xx-1982A	22	34	----	45	----	52	58	42.0	1.24	9.00	very skewed towards coarse	----	well
63.4750	Mathews Riffle	BS-rt004-xx-1982B	5	13	----	29	----	44	52	23.5	1.88	15.75	very skewed towards coarse	----	moderate
62.7802	Aleck Riffle	BS-rm005-xx-1982A	6	27	----	78	----	98	123	51.4	1.91	35.50	very skewed towards coarse	----	poor
62.7802	Aleck Riffle	BS-rm005-xx-1982B	1	2	----	9	----	36	46	7.3	4.90	17.25	skewed towards coarse	----	very poor
62.1785	Great Western	BS-rt006-xx-1982A	64	86	----	108	----	138	225	108.9	1.27	26.00	skewed towards fine	----	well
62.1785	Great Western	BS-rt006-xx-1982B	2	9	----	38	----	72	80	26.0	2.77	31.30	very skewed towards coarse	----	poor
61.1887	Robinson Riffle	BS-rt007-xx-1982A	1	2	----	19	----	78	88	13.4	5.82	37.85	skewed towards coarse	----	very poor
61.1887	Robinson Riffle	BS-rt007-xx-1982B	2	2	----	25	----	76	88	11.7	6.50	37.10	very skewed towards coarse	----	very poor
60.7118	Steep Riffle	BS-rt008-xx-1982A	1	4	----	25	----	58	78	15.6	3.72	26.90	very skewed towards coarse	----	very poor
60.7118	Steep Riffle	BS-rt008-xx-1982B	1	6	----	30	----	82	94	22.5	3.64	37.90	very skewed	----	very poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D₅ (mm)	D₁₆ (mm)	D₂₅ (mm)	D₅₀ (mm)	D₇₅ (mm)	D₈₄ (mm)	D₉₅ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer)	*Description of Kurtosis --- Frequency Distribution	Description of Sorting
													towards coarse		
60.4888	Weir Riffle	BS-rt009-xx-1982A	18	36	----	70	----	76	78	52.3	1.45	20.00	very skewed towards coarse	----	moderately well
60.4888	Weir Riffle	BS-rt009-xx-1982B	1	9	----	44	----	76	78	26.4	2.87	33.40	very skewed towards coarse	----	poor
59.5252	Gateway Riffle	BS-rt010-xx-1982A	37	52	----	78	----	88	96	67.6	1.30	18.00	very skewed towards coarse	----	well
59.5252	Gateway Riffle	BS-rt010-xx-1982B	7	19	----	37	----	59	78	33.5	1.76	20.00	skewed towards coarse	----	moderate
58.722	THERMALITO SPILLWAY														
58.4121	Sutter Butte Riffle	BS-rt011-xx-1982A	17	25	----	30	----	49	56	35.0	1.40	12.00	skewed towards fine	----	well
58.4121	Sutter Butte Riffle	BS-rt011-xx-1982B	1	11	----	21	----	46	54	22.0	2.09	17.75	skewed towards coarse	----	poor
57.1720	Conveyor Belt Riffle	BS-bt012-xx-1982A	4	11	----	52	----	74	80	28.5	2.59	31.50	very skewed towards coarse	----	poor
57.1720	Conveyor Belt Riffle	BS-bt012-xx-1982B	1	4	----	17	----	48	68	13.9	3.46	22.00	skewed towards coarse	----	poor
56.3586	Hour Riffle	BS-rm013-xx-1982A	3	18	----	64	----	84	90	38.9	2.16	33.00	very skewed towards coarse	----	poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D5 (mm)	D16 (mm)	D25 (mm)	D50 (mm)	D75 (mm)	D84 (mm)	D95 (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer)	*Description of Kurtosis --- Frequency Distribution	Description of Sorting
56.3586	Hour Riffle	BS-rm013-xx-1982B	1	3	----	23	----	64	62	13.9	4.62	30.50	very skewed towards coarse	----	very poor
54.6539	Keister Riffle	BS-rt014-xx-1982A	14	21	----	44	----	50	58	32.4	1.54	14.50	very skewed towards coarse	----	moderately well
54.6539	Keister Riffle	BS-rt014-xx-1982B	2	6	----	27	----	72	82	20.8	3.46	33.00	skewed towards coarse	----	poor
54.4165	Goose Riffle	BS-rt015-xx-1982A	2	12	----	44	----	74	76	29.2	2.54	31.25	very skewed towards coarse	----	poor
54.4165	Goose Riffle	BS-rt015-xx-1982B	1	3	----	19	----	56	80	13.4	4.18	26.40	very skewed towards coarse	----	very poor
53.5875	Big Riffle	BS-rt017-xx-1982A	1	2	----	15	----	60	84	9.8	6.12	29.20	skewed towards coarse	----	very poor
53.5875	Big Riffle	BS-rt017-xx-1982B	3	15	----	80	----	86	90	35.9	2.39	35.50	very skewed towards coarse	----	poor
53.5750	Big Riffle	BS-bt016-xx-1982A	1	9	----	40	----	66	78	24.6	2.68	28.40	very skewed towards coarse	----	poor
53.5750	Big Riffle	BS-bt016-xx-1982B	1	3	----	23	----	72	84	14.4	4.98	34.55	very skewed towards coarse	----	very poor
52.2046	MacFarland Riffle	BS-rt018-xx-1982A	4	16	----	50	----	80	88	35.8	2.24	32.00	very skewed	----	poor

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River Mile (USACE)	Riffle/Feature	Office Code*	D5 (mm)	D16 (mm)	D25 (mm)	D50 (mm)	D75 (mm)	D84 (mm)	D95 (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer)	*Description of Kurtosis --- Frequency Distribution	Description of Sorting
													towards coarse		
52.2046	MacFarland Riffle	BS-rt018-xx-1982B	3	7	----	38	----	96	112	26.5	3.63	44.35	very skewed towards coarse	----	poor
50.545	GRIDLEY HIGHWAY BRIDGE														
49.3999	Gridley	BS-rt019-xx-1982A	1	2	----	18	----	46	78	9.1	5.06	22.10	very skewed towards coarse	----	very poor
49.3999	Gridley	BS-rt019-xx-1982B	1	9	----	38	----	46	55	20.3	2.26	18.50	very skewed towards coarse	----	poor
44.315	HONCUT CREEK														

* Kurtosis not calculated for this year because D_{75} and D_{25} values are unavailable.

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Table 5.2-5. Feather River Gravel Sampling ---DWR Bulk Samples of Tailings Collected between Thermalito Diversion Dam and Honcut Creek (2002-03)

River Mile (USACE)	Riffle/Feature	Office Code	D5 (mm)	D16 (mm)	D25 (mm)	D50 (mm)	D75 (mm)	D84 (mm)	D95 (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
* "Office Code" is defined sequentially by the following: 1) Type of sample --- BS = bulk sample, WS = Wolman sample; 2) Feature --- r = riffle, b = bar, g = glide, t = tailings, blank = unspecified; 3) Location --- t = top (upstream) end of feature, m = middle of feature, b = bottom (downstream) end of feature, blank = unspecified; 4) Number --- consecutive numbering consistent in 1982, 1996, 2002/2003;							5) Local feature --- d = dune, t = trough, e = embedded, blank = unspecified; 6) Year--- year that this site was last sampled --- main years of sampling are 1982, 1996 and 2002/2003, xx means this is the first year sampled; 7) Year--- year that this sample was taken; 8) Vertical stratum sampled --- A = surface, B = subsurface, C = both								
71.500	OROVILLE DAM														
67.128	THERMALITO DIVERSION DAM														
66.541	FISH BARRIER DAM														
66.283	TABLE MOUNTAIN BRIDGE														
65.002	HIGHWAY 70 BRIDGE														
63.872	HIGHWAY 162 BRIDGE														
63.1960	Mathews/Aleck Tailings	BS-TP-t002-xx-2003A	8	17	23	46	79	109	168	42.7	2.55	46.13	skewed towards coarse	normal	poor
63.1843	Mathews/Aleck Tailings	BS-TP-t001/002-xx-2003C	0	0	1	11	65	107	164	6.5	16.50	53.09	skewed towards coarse	very flat	very poor
63.1727	Mathews/Aleck Tailings	BS-TP-t001-xx-2003T	1	11	13	24	43	57	90	24.5	2.33	23.30	skewed towards coarse	very highly peaked	poor
63.1727	Mathews/Aleck Tailings	BS-TP-t001-xx-2003M	6	21	27	53	95	115	147	49.0	2.35	47.24	skewed towards coarse	normal	poor

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River Mile (USACE)	Riffle/Feature	Office Code	D_5 (mm)	D_{16} (mm)	D_{25} (mm)	D_{50} (mm)	D_{75} (mm)	D_{84} (mm)	D_{95} (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
63.1727	Mathews/Aleck Tailings	BS-TP-t001-xx-2003B	0	4	11	30	67	94	149	18.6	5.07	45.20	very skewed towards coarse	highly peaked	very poor
63.1727	Mathews/Aleck Tailings	BS-TP-t001-xx-2003C	1	11	17	39	73	102	158	32.7	3.11	45.64	very skewed towards coarse	very highly peaked	very poor
62.7442	Aleck Tailings	BS-TP-t008-xx-2003T	0	0	7	32	95	148	183	7.6	19.45	74.01	very skewed towards coarse	highly peaked	very poor
62.7442	Aleck Tailings	BS-TP-t008-xx-2003B	0	0	0	13	32	44	75	3.0	14.70	22.08	very skewed towards coarse	flat	very poor
62.7442	Aleck Tailings	BS-TP-t008-xx-2003C	0	20	31	86	161	174	191	59.6	2.92	76.68	very skewed towards coarse	very highly peaked	very poor
58.7672	Thermalito Outflow Tailings	BS-TP-t006-xx-2003T	0	3	9	29	76	108	166	19.4	5.58	52.32	very skewed towards coarse	highly peaked	very poor
58.7672	Thermalito Outflow Tailings	BS-TP-t006-xx-2003M	1	10	17	48	99	125	170	35.0	3.57	57.61	very skewed towards coarse	highly peaked	very poor
58.7672	Thermalito Outflow Tailings	BS-TP-t006-xx-2003B	2	13	22	60	107	129	167	40.6	3.18	58.13	very skewed towards coarse	highly peaked	poor
58.7672	Thermalito Outflow Tailings	BS-TP-t006-xx-2003C	5	14	23	55	105	132	175	43.2	3.05	58.92	skewed towards	normal	poor

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River Mile (USACE)	Riffle/Feature	Office Code	D$_5$ (mm)	D$_{16}$ (mm)	D$_{25}$ (mm)	D$_{50}$ (mm)	D$_{75}$ (mm)	D$_{84}$ (mm)	D$_{95}$ (mm)	Dg (mm)	Sigma - root of percentile method	Standard Deviation (mm)	Description of Skewness (negative = coarser, positive = finer) (Warren, 1974)	Description of Kurtosis --- Frequency Distribution (Folk and Ward, 1957)	Description of Sorting (Folk and Ward, 1957)
													coarse		
58.722	THERMALITO SPILLWAY														
58.6798	Thermalito Outflow Tailings	BS-TP-t007-xx-2003A	11	21	28	51	93	121	174	50.5	2.39	49.83	symmetrical	normal	poor
53.8899	Goose Backwater Tailings	BS-TP-t005-xx-2003A	0	3	9	32	68	92	141	16.4	5.63	44.79	very skewed towards coarse	highly peaked	very poor
50.545	GRIDLEY HIGHWAY BRIDGE														
44.315	HONCUT CREEK														

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The High Flow Reach is also armored, with a D_{50} armoring ratio averaging between two and three.

There is a large range in the degree of armoring for the 2002-3 sampling in both reaches, with a ratio from less than one to over six. The range in the armoring ratio is not nearly as dramatic for the 1982 and 1996 data.

5.2.5.2 Artificial Gravel Augmentation

The statistical parameters of imported spawning gravel for Moes ditch in 1982 are considerably finer than the native gravel. Sampling was done at the toe of Moes Ditch where imported gravel was deposited after being scoured from the upper ditch area. This redistribution of gravel shows that material will move down through the river system and provide beneficial use as it moves from one riffle to another.
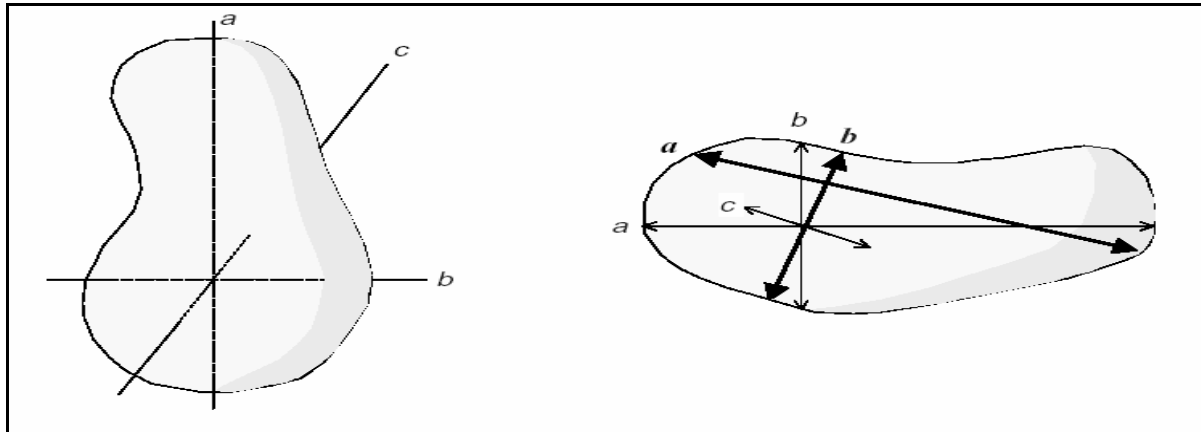
Gravel placed in the early 1980's is still visible in Hatchery riffle. This suggests that some gravel may survive large flow events at key sites.

5.3   SURFACE GRAVEL SAMPLING (WOLMAN)

Surface sampling has several advantages over bulk sampling. First it provides a more representative sample because of the larger aerial extent. Second, it is faster and cheaper. It is mostly applicable to coarser material found on the surface. Finer sediment, however, is not well represented.

Surface samples were taken at 20 riffles using a modified Wolman (1954) grid method. The area sampled included or was immediately adjacent to the bulk sample site.

The Wolman method, with minor variations, was selected because of its relative simplicity and common usage. This method requires that individual stones be measured on the intermediate or b-axis by ruler or calipers, or classified using square openings in a template. In 2002 to 2003 a ruler was used. The axes of a particle are shown in Figure 5.3-1 (Yuzyk and Winkler 1991).

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Figure 5.3-1. Definition of Particle Axes.

The distance between successively sampled particles is significant because of the propensity for particles of similar size to imbricate. The sample grid is chosen, usually on a 2.5 or 5 foot spacing, so that successively selected particles are at least several grain diameters apart. This is done by laying out two or three tapes to keep the sampling evenly spaced and taking a step or steps between each sample point. After each pace(s), the eyes are closed; the first particle touched with a pointer is picked up. The particle's b-axis is measured and recorded. This is continued until 100+ samples are recorded. The grid is tied into world coordinates by using the GPS to record a point within the grid. A Wolman site is shown in Photograph 5.3-1

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Photo 5.3-1. Wolman Grid Setup at Weir Riffle

The b-axis measurement is taken with a ruler scaled in millimeters and then later converted to phi units, with phi = -$\log_2$ of the b-axis diameter in millimeters. The *b*-axis measurement was measured to simulate the way a particle drops through a sieve opening. This was done to compare the Wolman counts with bulk samples

Wolman counts were conducted at the same site as the bulk sampling. Wolman counts (grid-by-number) and Surface bulk samples (volume-by-weight) are roughly equivalent. We applied no conversion factor to compare the two sampling methods, as recommended by Church et al (1987) although there is a considerable amount of controversy surrounding this subject.

Wolman counts do not adequately sample the finer sediments. Wolman size fractions with a phi of 0 (1-millimeter) and finer were lumped in the 0-size category. Wolman surface counts are not equivalent to subsurface bulk samples in an armored-bed stream, although conversion factors or graphs can be developed that allow this comparison. Pebble counts take between 0.5 and 1 hour per sample, depending on the number of particles to be collected and the difficulty involved in dislodging particles from the bed; however, no further laboratory time is needed.
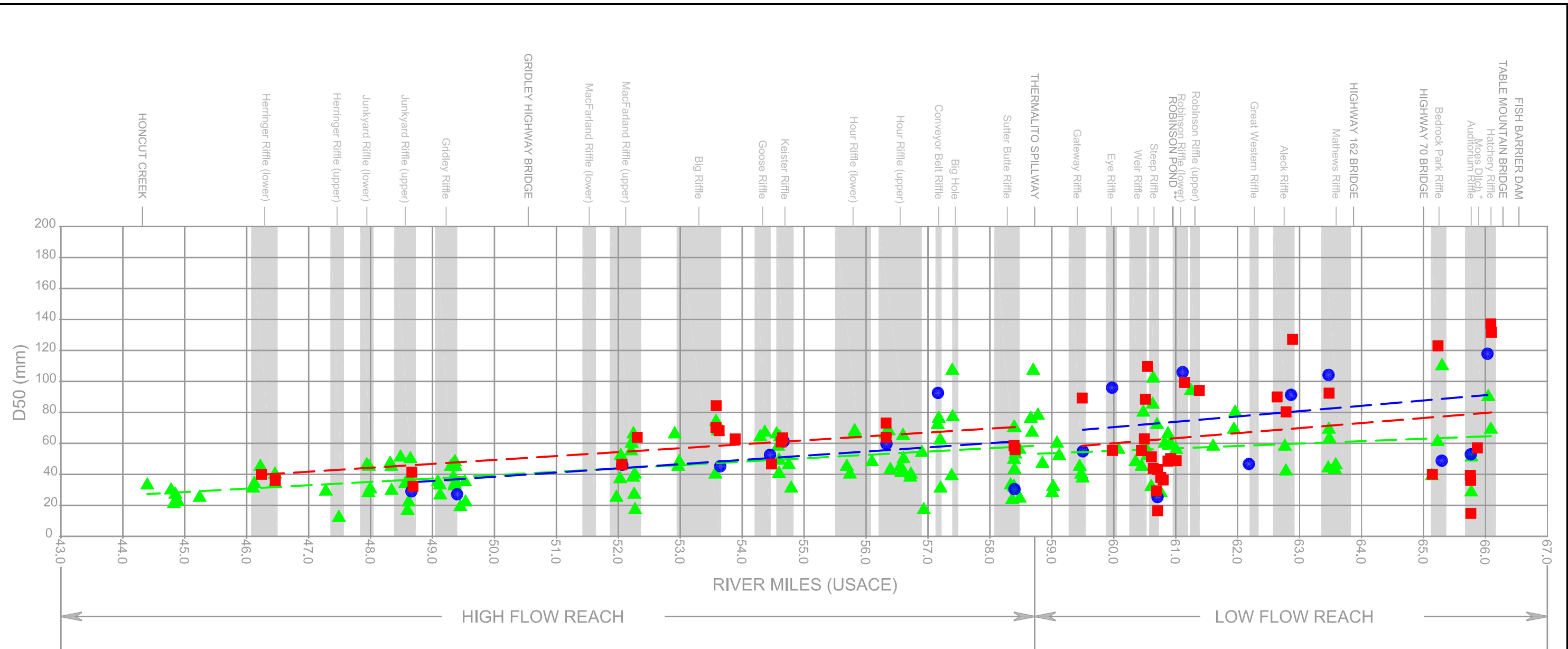
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5.3.1 Surface Sampling Results

Statistical parameters for the 2002-03 surface sampling are presented in Table 5.3-1. The results are also shown on the Wolman Sample particle size distribution graphs in Appendix A. Table 5.3-2 shows the 1996 data and Table 5.3-3 shows the 1982 sampling data. Table 5.3-4 shows the results from the tailings pile analyses.

Figure 5.3-2 shows the trend in gravel diameter D_{50} for the Wolman surface gravel sampling. Note that most of the samples were taken at the head of the riffle, but some of the samples were taken at mid- and tail end of riffles. The Wolman results show a general fining in the downstream direction. There is also a general coarsening trend from 1982 to 2003, but the samples taken at Moes ditch (a gravel augmentation project) tends to drive the linear best fit line down.

Figure 5.3-3 shows the Dg for the Wolman surface gravel sampling. The linear best fit lines, as expected are somewhat lower, but similar to the D_{50} results.

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Figure 5.3-2. Wolman Gravel Sample D$_{50}$s

LEGEND

- ■ 2003 Wolman Sample D50
- ● 1996 Wolman Sample D50
- ▲ 1982 Wolman Sample D50
- – – – – 2003 Wolman Sample D50 -Linear Best Fit
- – – – – 1996 Wolman Sample D50 - Linear Best Fit
- – – – – 1982 Wolman Sample D50 - Linear Best Fit

NOTES

1) River miles based on USACE 1997 river center line. 0.0 = Feather River intersection with Sacramento River.
2) D50 - b-axis in millimeters.
3) * Spawning gravel injection at Moe's Ditch from 1971 to 1982, therefore, Linear Best Fits do not include these samples.
4) ** Robinson Pond - apparent gravel trap

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FIGURE 5.3-2
SP-G2 TASK 2

WOLMAN GRAVEL SAMPLE
D50s

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Figure 5.3-3. Wolman Gravel Sample Dgs

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FIGURE 5.3-3
SP-G2 TASK 2

WOLMAN GRAVEL SAMPLE
Dgs

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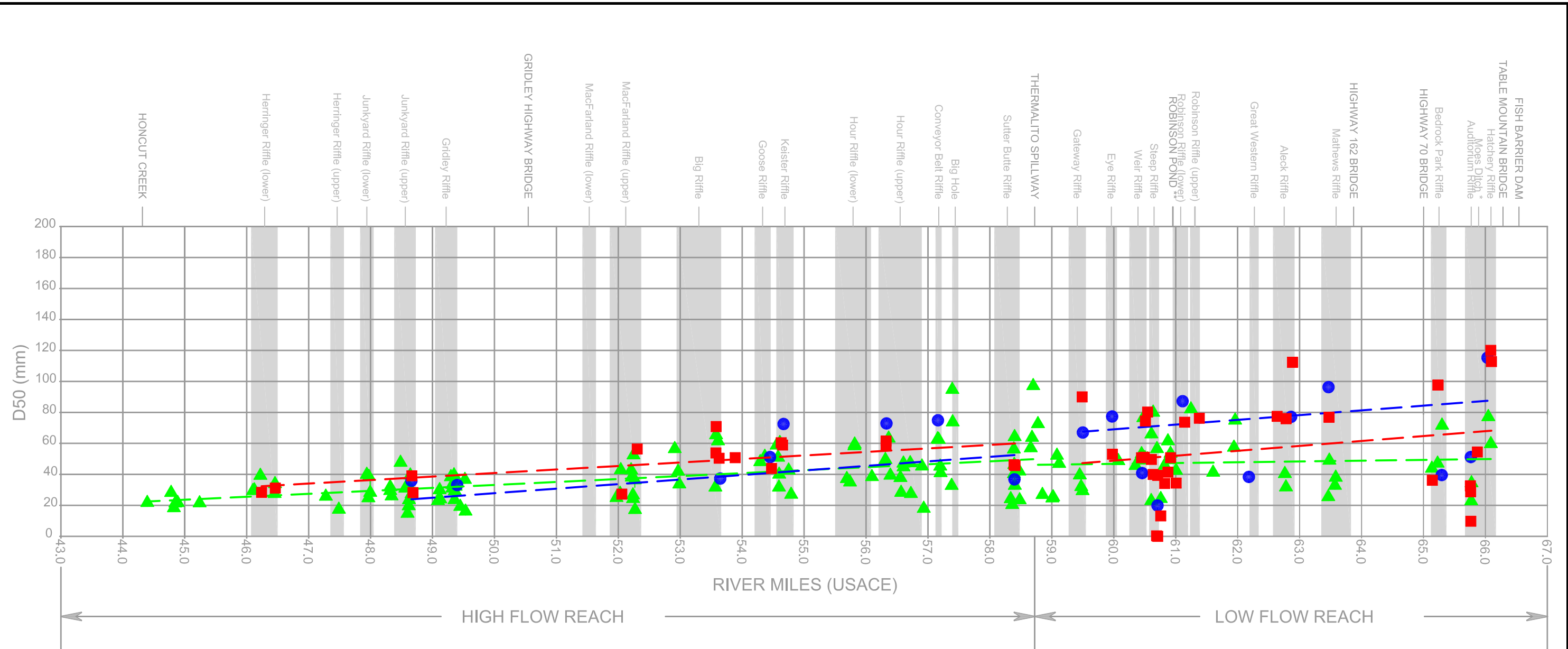
LEGEND

■ 2003 Wolman Sample Dg

● 1996 Wolman Sample Dg

▲ 1982 Wolman Sample Dg

— — — 2003 Wolman Sample Dg -Linear Best Fit

— — — 1996 Wolman Sample Dg - Linear Best Fit

— — — 1982 Wolman Sample Dg - Linear Best Fit

NOTES
1) River miles based on USACE 1997 river center line. 0.0 = Feather
   River intersection with Sacramento River.
2) Dg - b-axis in millimeters.
3) * Spawning gravel injection at Moe's Ditch from 1971 to 1982,
   therefore, Linear Best Fits do not include these samples.
4) ** Robinson Pond - apparent gravel trap

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